

OPIC

OFFICE DE LA PROPRIÉTÉ  
INTELLECTUELLE DU CANADA



CIPO

CANADIAN INTELLECTUAL  
PROPERTY OFFICE

(12) (19) (CA) **Demande-Application**

(21) (A1) **2,207,499**

(22) 1997/06/10

(43) 1998/12/10

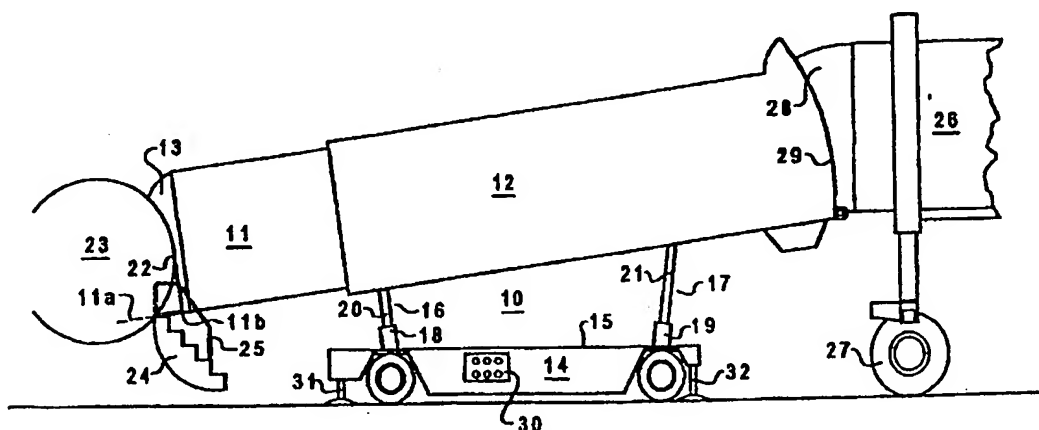
(72) ROLFE, Daniel, CA  
(72) POTHIER, Jacqueline, CA  
(72) SMITH, Brian, CA  
(72) STANDRING, Robert, CA  
(72) BOUDREAU, Jean, CA  
(72) FREEDMAN, Gordon S., CA  
(72) BORZA, Michael A., CA  
(71) DEW ENGINEERING AND DEVELOPMENT LTD., CA

**BEST AVAILABLE COPY**

(51) Int.Cl.<sup>6</sup> B64F 1/315

(54) **PONT D'EMBARQUEMENT POUR PETITS AVIONS ET  
METHODE D'ALIGNEMENT DE CELUI-CI**

(54) **PASSENGER LOADING BRIDGE FOR SMALL AIRCRAFT AND  
METHOD OF ALIGNING SAME**



(57) Cette invention concerne un pont d'embarquement adapté pour permettre le transfert des passagers depuis le rez-de-chaussée d'une aérogare à un avion de transport régional à garde au sol comprise entre 40 pouces et 108 pouces ou plus. Le pont comprend une rotonde pivotante et une passerelle se prolongeant jusqu'à l'avion. La passerelle est montée sur un chariot dont les roues sont parallèles à l'axe de la passerelle et qui est équipé de vérins hydrauliques de levage d'une partie de la passerelle. En position abaissée, la passerelle repose entre les roues du chariot. L'avion se stationne perpendiculairement à la passerelle, sa porte d'accès étant dans le prolongement de la partie télescopique de celle-ci. Cette partie télescopique est inclinée vers le bas par rapport au point le plus élevé du pont lorsqu'il s'agit d'assurer le transfert des passagers dans un très petit avion.

(57) A passenger loading bridge is disclosed for bridging passengers between a ground floor terminal and commuter aircraft from as low as 40 inches to as high as 108 inches or higher. The bridge has a rotating rotunda and walkway extending therefrom to an aircraft. The walkway is supported by a gantry having wheels directed laterally to the walkway and on opposing sides thereof and a hydraulic lifting mechanism for lifting and lowering an end of the walkway. When lowered, the walkway rests between the wheels. The aircraft interface is at right angles to the walkway and is on an extensible section of the walkway. The extensible section of the walkway angles down from the walkway's highest point when the walkway is completely lowered allowing for bridging from a ground level terminal to very small aircraft.



Industrie Canada Industry Canada

**Abstract of the Disclosure**

A passenger loading bridge is disclosed for bridging passengers between a ground floor terminal and commuter aircraft from as low as 40 inches to as high as 108 inches or higher. The bridge has a rotating rotunda and walkway extending therefrom to an aircraft.

- 5 The walkway is supported by a gantry having wheels directed laterally to the walkway and on opposing sides thereof and a hydraulic lifting mechanism for lifting and lowering an end of the walkway. When lowered, the walkway rests between the wheels. The aircraft interface is at right angles to the walkway and is on an extensible section of the walkway. The extensible section of the walkway angles down from the walkway's
- 10 highest point when the walkway is completely lowered allowing for bridging from a ground level terminal to very small aircraft.

**Passenger Loading bridge for Small Aircraft and Method of Aligning Same****Field of the Invention**

The invention relates generally to passenger loading bridges and, in particular, to a swinging-type passenger loading bridge for use at ground level airport terminals.

**5 Background of the Invention**

Passenger loading bridges have gained world-wide acceptance for the safety and convenience they afford passengers. Most major air terminals are provided with passenger loading bridges which extend from the second level of the terminal to a parked aircraft. Frequently, these bridges are relatively immobile since aircraft can park close to  
10 the terminal and be moved away by tugs or tractors.

Commonly, passenger loading bridges have been directed to standard size passenger and cargo aircraft and consequently, have been relatively large in size and height. They have not generally been practicable for use with small aircraft such as, those employed in feeder lines to smaller or outlying communities. Accordingly, persons  
15 emplaning or deplaning to and from small aircraft typically have had to walk from a doorway or the like over airport tarmac and thence, up a stairway in order to enter a small aircraft. When deplaning, just the reverse occurs, thus exposing passengers to inclement weather and hazards such as propellers, cables, and fuelling hoses. Therefore, there has continued to be a need for a highly adjustable and enclosed passenger or cargo  
20 loading/unloading bridge that can be advantageously utilised with such small aircraft.

Commonly, smaller air terminals are only ground level structures at which aircraft park a fixed distance from the terminal building. There frequently are no tugs available. This fixed distance is required to enable the aircraft to "power out" or move away from the building under its own power without damaging the building with a jet or propeller  
25 blast, or a physical collision between the aircraft and the terminal. This distance is

greatest with a Boeing 727-200 aircraft, which is the largest aircraft normally serving these smaller terminals. Passengers walk in the open out to the aircraft and up an open staircase into the plane. It is not desirable to subject passengers to inclement weather or to potentially dangerous ramp conditions. Also, aircraft operations are significantly slowed  
5 by allowing passengers onto the tarmac. For safety reasons, aircraft and equipment remain stationary while passengers are on the tarmac. Security is a concern because passengers can board incorrect aircraft or tamper with other craft. In order to increase security, it is a common practice to board only one aircraft from the tarmac at any time. With passenger loading bridges in place, luggage is loaded, aircraft tests are executed,  
10 other aircraft are taxied, and so on while passengers board the aircraft. Other aircraft are capable of being boarded simultaneously when sufficient gates exist. It is therefore desirable to provide a passenger loading bridge for use at these smaller air terminals to enhance the safety and comfort of passengers.

A prior art type-of ground level loading bridge is shown in U.S. Pat. No.  
15 3,110,048 in the name of Bolton, which illustrates a bridge having a rotunda, tunnel, stairs to aircraft level, and a tunnel which extends to the aircraft. The juncture of the stairs and the tunnel is provided with an arcuate track with co-operating wheels to support the load of the bridge. The wheels are provided with mean to elevate the entire tunnel and stairs to accommodate different aircraft. Of course, such a structure is undesirable  
20 because of limited access for the physically disabled and other liabilities associated with stairs.

When ramps for planing and deplaning mate with an opening in a second floor of an airport terminal, the height of the two ends of the ramp are most conveniently aligned when the ramp is to an entrance of a jumbo jet - both being a similar distance from the  
25 ground. Because of the small size of many commuter aircraft, a ramp from a ground level terminal to the entrance of a small aircraft must have both openings near ground level. Unfortunately, the height of other commuter aircraft requires a ramp from ground level to

9 feet from the ground. Because of the mechanism for moving and lifting the ramp, ramps can not lower themselves sufficiently to function from a ground level entrance of a terminal to an entrance of a small commuter aircraft.

In U.S. Patent 4,161,049 issued to Saunders et al. on July 17, 1979, a passenger loading bridge for a ground level terminal is disclosed. In order to accommodate small aircraft, a stairway from a rotunda to a walkway is provided. The stairway permits an end of the walkway proximate the terminal to be raised to or above the minimum height of the supports for raising and lowering the walkway proximate an aircraft and therefor allows the walkway to mate with aircraft entrances that are disposed in line with the minimum support height. As indicated above, it is undesirable to provide stairs for passenger use in a passenger loading bridge. Replacing the stairs with a ramp results in a steep ramp that is itself undesirable or in an unduly long ramp. Further, replacing the stairs with a long ramp results in forces being applied to the rotunda which will increase wear on rotating parts and, in some instances, will result in failure of the rotating mechanism.

It would be advantageous to provide a passenger loading bridge that is capable of mating with an airport at ground level and with small and large commuter aircraft.

When coupling available passenger loading bridges to aircraft such as jumbo jets, a significant clearance exists between the engines and the aircraft entrance. Also, as the entrance to a jumbo jet is displaced from the ground by a considerable distance, collisions with personnel, baggage, or vehicles on the ground is unlikely. In contrast, the entrance for a Dash 8 is less than 4 feet from the ground. An aircraft interface approaching the entrance is susceptible to damaging vehicles and hurting people. Also, because a small aircraft has significantly less clearance between the propellers and the entrance than jumbo jets, current passenger loading bridges require several people to guide them into an

engaged position. Even with the efforts of a number of people, damage to the aircraft is likely due to very small clearance distances.

It would be advantageous to provide a passenger loading bridge that reduces a likelihood of damaging an aircraft and increases personnel safety.

5

### Statement of the Invention

In accordance with the invention, there is provided a passenger loading bridge for interconnecting an aircraft having an entrance therein with the ground level of an airport terminal building comprising:

10 a walkway-conduit including:

- a first open end,

- an extensible section proximate an opposing end thereof comprising an aircraft interface for mating with the aircraft entrance,

- elevation means for elevating the aircraft interface to allow the aircraft interface to engage each of a plurality of different sized commuter aircraft,, and

15

- horizontal pivot means for pivoting the walkway about a rotunda;

the rotunda having a first open end coupled to the airport terminal building substantially at ground level and a second open end movable relative to said first open end of the rotunda, the second open end hingedly connected to the first open end of the walkway for allowing the rotunda to remain substantially level and for allowing the aircraft interface to be elevated, wherein the horizontal pivot means is for moving the second open end of the rotunda relative to the first open end of the rotunda..

20

25 In an embodiment, the walkway comprises:

- a first walkway portion hingedly coupled to the rotunda;

a second walkway portion hingedly connected to the first walkway portion for allowing the second walkway portion to angle downwardly from the hinged connection, the second walkway portion having the aircraft engaging opening disposed proximate an end thereof; and, wherein the elevation means is disposed to raise and lower the walkway such that the  
5 hinged connection between the first and second portions forms an obtuse angle peak the walkway descending from the peak toward either side when the walkway is fully lowered.

In another embodiment, the walkway comprises:

10 a first walkway portion hingedly coupled to the rotunda; and,  
a second walkway portion connected to the first walkway portion and angling downwardly from the connection, the second walkway portion having the aircraft interface disposed proximate an end thereof.

15 In an embodiment, the first opening of the rotunda is connected to two substantially circular rails disposed one above the other and wherein the second opening in the rotunda is connected to a plurality of bearings disposed between the rails and for rolling on either the bottom rail or the top rail.

20 Preferably, the two rails forms a fixed base for the rotunda relative to the ground.

In an embodiment, the aircraft interface comprises a bumper disposed along the bottom of the interface for engaging the aircraft, a gasket disposed substantially above the opening for engaging the aircraft above the opening and for forming a protective covering for  
25 passengers passing between the aircraft and the passenger loading bridge.

In an embodiment, the bottom of the aircraft interface comprises a plurality of slots for accepting railings disposed on staircases affixed to aircraft.

In accordance with the invention there is further provided a passenger loading bridge for interconnecting an aircraft having an entrance therein with the ground level of an airport terminal building comprising:

5 a walkway conduit including:

a first opening at an end thereof,

an extensible section proximate an opposing end thereof comprising an aircraft interface for mating with the aircraft entrance,

10 elevation means for elevating the aircraft interface to allow the aircraft interface to engage each of a plurality of different sized commuter aircraft,

horizontal pivot means for pivoting the walkway about a rotunda, and

sensors for detecting the presence of an object proximate the walkway and for providing signals in dependence thereon;

15 the rotunda having a first opening connected to the airport terminal building substantially at ground level and a second opening movable relative to said first opening of the rotunda, the second opening hingedly connected to the first opening in the walkway for allowing the rotunda to remain substantially level and for allowing the aircraft interface to be elevated, wherein the horizontal pivot means is for moving the second opening of the rotunda relative to the first opening of the rotunda; and,

20 means responsive to the signals provided by the sensors for stopping at least one of the horizontal pivot means and the elevation means when an object is detected in a path of motion of the walkway.

25 According to another aspect of the invention, there is provided a method of automatically aligning an aircraft interface of a passenger loading bridge and an entrance to an aircraft comprising the steps of:

determining an approximate height of the entrance;

moving the aircraft interface to substantially the approximate height;



moving the aircraft interface toward the aircraft;  
detecting a presence of objects in the path of movement of the passenger loading bridge  
using sensors;  
when possible, moving portions of the passenger loading bridge to avoid detected objects;  
5 when objects cannot be avoided, stopping the passenger loading bridge motion until  
objects are cleared;  
upon approaching the aircraft, aligning a bumper of the aircraft interface with the  
entrance; and  
moving the aircraft interface to engage the aircraft with the bumper.

10

### **Brief Description of the Drawings**

An exemplary embodiment of the invention will now be discussed in conjunction with  
the attached drawings in which:

- Fig. 1 is a side elevation view of the propellable bridge assembly illustrating a mobile  
15 supporting platform, a pair of vertical supports and an enclosed bridge structure  
according to the prior art;  
Fig. 2 is top view of a passenger loading bridge according to the invention and  
comprising an interface unit, a rotunda, a walkway, a head unit supported by a gantry,  
and an aircraft interface;  
20 Fig. 3 is side view of the passenger loading bridge of Fig. 2 in an elevated position;  
Fig. 4 is side view of the passenger loading bridge of Fig. 2 in a lowered position;  
Fig. 5a is an illustration of a passenger loading bridge coupled to a second story terminal  
gate;  
Fig. 5b is an illustration of a passenger loading bridge coupled to a ground level terminal  
25 gate;

Fig. 6 is top view of a passenger loading bridge according to the invention and comprising an interface unit, a rotunda, a walkway, a head unit supported by a gantry, and an aircraft interface;

5 Figs. 7a, 7b, 7c, 7d, 7e, 7f, 7g, 7h, and 7i are diagrams of the rotunda of the passenger loading bridge according to the invention;

Fig. 8 is a diagram of a control console for use with a passenger loading bridge according to the invention;

Figs. 9a, 9b, and 9c are diagrams of a retracting or "flip-out" control console for use with a passenger loading bridge according to the invention;

10 Figs. 10a, 10b, 10c, 10d, and 10e, are detailed diagrams of the gantry shown in Fig. 2;

Fig. 11 is a method of adjusting aircraft interface height automatically;

Fig. 12 is a flow diagram of a method of aligning the passenger loading bridge with an aircraft;

15 Fig. 13 is a flow diagram of a method of aligning the passenger loading bridge with an aircraft;

Figs. 14a and 14b are simplified flow diagrams of methods of training the automatic alignment system for the passenger loading bridge and,

Fig. 15 is a simplified diagram of a side of the canopy showing the canopy extension mechanism.

## 20 Detailed Description of the Invention

Referring to Fig. 1, a prior art propellable telescoping bridge assembly 10 comprises a forward telescoping bridge section 11, a rear telescoping bridge section 12, a forward extension 13, and a mobile supporting platform 14. Extending upwardly from upper portion 15 of platform 14 are forward rectilinear support 16 and rear rectilinear support 17. Such supports are sufficiently wide and deep so as to obviate any necessity for additional vertical supports.

25

To facilitate positioning of the forward and rear bridge sections 11 and 12, supports 16 and 17 are provided with hydraulic cylinders 18 and 19 that are independently operable in response to controls such as those represented by control panel 30. As is known to those skilled in the art, such cylinders extend and retract extending portions 20 and 21 so as to controllably pivot the longitudinal axis of bridge sections 11 and 12 in such manner as to align the forward extension 13 of forward telescoping bridge section 11 with the entry/exit hatch 22 of small aircraft 23.

Some small aircraft are equipped with moveable stairs that swing downwardly when their entry/exit hatch is opened, and such stair and its associated railing are identified with numerals 24 and 25. Of course, it will be understood that when the bridge assembly 10 is disposed as shown, stairs 24 and railing 25 are not used. As is clear from the drawing, the railings 25 must fit outside the forward telescoping bridge section or they are prone to damage from collisions and the bridge is likely incapable of engaging a side of an aircraft.

Further reference to the front of the forward section 11 reveals the presence of an optional swing down extension that is represented by dashed lines 11a. Such optional swing down extension may preferably be pivoted by a hinge 11b that connects it to the floor of extension 11 and is provided so as to accommodate the narrow exit/entry doors that are provided in some small aircraft. Of course, as will be evident to those skilled in the art, a similar hinged swing down extension may optionally be provided at the opposite end of the bridge.

Also shown in FIG. 1 is a conventional large aircraft loading/unloading bridge 26 which is typically supported in part by a conventional wheel 27. As is known to those skilled in the art, such a conventional bridge is typically equipped with an adjustable forward extension such as extension 28, and to facilitate engagement therewith, there is provided along the rear terminus of rear bridge section 12, a conforming curved surface

29. Such conforming curved surface preferably simulates the curvature of a conventional large aircraft (not shown) for which large aircraft loading bridge 26 is designed.

As known to those skilled in the art, telescoping bridge sections are extended and retracted with conventional powered controls, and to facilitate extension and retraction of forward section 11 of the bridge, such conventional controls are provided within section 12 or on the control panel 30 of mobile supporting platform 14.

When extensions 20 and 21 are extended to different lengths, the bases will tend to swing slightly through small arcs. Accordingly, provision is made to accommodate the swing through the inclusion of conventional swivels or the like (not shown). Provision also is made to secure the bridge, when deployed in its desired position, through the lowering of four hydraulic stabilising jacks that firmly engage upper surfaces of the airport tarmac. Such jacks (represented by jacks 31 and 32) are preferably located near the four corners of the supporting platform 14 and are controlled by conventional controls that are included among those of control panel 30.

As is evident upon review of Fig. 1, in order to engage small aircraft, it is essential that conforming curved surface 29 be disposed a significant distance above the tarmac. This enables the extensions 20 and 21 to rest below the rear bridge section 12 above the wheels. Further, stability is provided by the jacks 31 and 32. These jacks support members and as such are costly. It would be advantageous to design an aircraft passenger bridge that does not need stabilisers in the form of structural members.

Referring to Fig. 2, a top view of an aircraft walkway is shown. A terminal 100 is provided with a plurality of gates. At gate 8 is affixed a passenger loading bridge. The passenger loading bridge comprises an interface unit in the form of a valet unit 102 for connection to the terminal 100. The valet unit 102 is provided with a service ramp 104 and a passenger ramp 106. These ramps are well known in the art of passenger loading bridge design. To the valet unit 102 is attached a rotunda 104. The rotunda 104 comprises

a revolving section 106 for allowing the distant end of the passenger loading bridge to pivot relative to the airport terminal 100 about the rotunda 104. The rotunda 104 remains enclosed during passenger loading bridge movement thereby ensuring that the passenger loading bridge is protected from the elements. The rotunda comprises edge strip 105 for  
5 interfacing with the valet unit 102, a bellows 107, and an walkway unit interface 109.

Attached to the rotunda 104 by way of a hinged connection (shown in Fig. 2) is a walkway section 110a. Walkway sections 110a, 110b, ..., 110n are disposed end on end to produce a passenger loading bridge of a desired length. In the drawing of Fig. 1, 3 walkway units are shown. To the end of the walkway units 110 distant the rotunda 104, is  
10 attached a head unit 120. The head unit 120 comprises a walkway unit similar to the walkway units 110 but provided with additional features. Examples of these features include safety features in the form of an emergency exit stairway 112, a gantry 130 mounted to the head unit 120, and an aircraft interface 140.

As is shown in Fig. 2, the gantry 130 is provided with wheels 132 that allow for  
15 lateral motion of the passenger loading bridge. Because the rotunda 104 is fixed and allows rotation of the walkway portion of the passenger loading bridge, moving the gantry 130 causes the entire walkway portion of the passenger loading bridge to swing through the arc shown.

Referring to Fig. 3, a side view of the passenger loading bridge is shown in which  
20 the walkway portion is lifted to engage an opening in an aircraft that is 9 feet above the ground. The walkway portion of the passenger loading bridge is elevated using elevators comprising support beams 124 extending vertically on either side of the head unit 120 and an elevator power unit (not shown) in the form of a hydraulic lift. Placing the support beams 124 on either side of the head unit 120 allows head unit 120 to be lowered to level  
25 just clearing the gantry frame as is described with reference to Fig. 10 below. The elevator is collinear with the support beams 124 thereby retaining a space below the head unit 120 free of obstruction; this allows the head unit to descend substantially farther than

with devices according to the prior art. The rotunda 104 remains substantially horizontal and the walkway units 110 are angled upward. The hinged connection in the form of bellows 107 between the rotunda 104 and the walkway units 110 is evident. When the head unit 120 is elevated, the emergency exit stairs 113 are extended to allow for emergency exit use. The wheels 132 of the gantry 130 are well below the base of the head unit 120 and the angle of the walkway sections 110 is determined by the desired height of the aircraft interface 140. Where safety and accessibility for passengers with physical disabilities is of concern, sufficient walkway units 110 are inserted to ensure the angle is not excessive. For a 9 foot rise, a walkway length of about 100 feet including the head unit 120 is desirable.

The head unit is fixedly connected to the walkway unit 110n at a small angle by connection 122. As is seen in Fig. 3, the head unit is disposed at a less steep angle than the walkway unit 110n thereby permitting a more comfortable transition between the aircraft interface 140 and the aircraft entrance (not shown).

Referring to Fig. 4, the tilt of the head unit 120 is shown to allow lowering of the aircraft interface 140 to a level below the top of the gantry wheels 132. At this height, the emergency exit stairs 113 are collapsed. Preferably, at this height, the stairs 113 are formed into a ramp for serving a same purpose. Lowering the head unit 120 below the top of the gantry wheels 132 allows for a short head unit length to provide the desired reduction in aircraft interface height. Should the gantry 130 always remain below the head unit 120, a longer head unit is necessary to mate with a lower aircraft opening because the point F is necessarily higher than in the drawing of Fig. 4. Of course, lengthening the head unit or the walkway section of the passenger loading bridge increases overall cost and space required on the apron and is undesirable.

Optionally, the walkway unit 100n is coupled to the head unit 120 by a hinged connection. The head unit is disposed at a less steep angle than the walkway unit 110n thereby permitting a more comfortable transition between the aircraft interface 140 and

the aircraft entrance (not shown). In the design shown, this is accomplished using the force of gravity. By placing more of the head unit 120 - by weight - on the side of the gantry 130 proximate the aircraft interface 140 than on the side of the gantry 130 proximate the rotunda 104, the head unit 120 tilts downward naturally toward the aircraft entrance. Optionally, the head unit 120 is in line with the walkway units.

Current commercially available passenger loading bridges do not support coupling a ground level terminal to an aircraft having a doorway less than 2 feet from the ground. Referring to Fig. 5a, a passenger loading bridge 51 for coupling with a second story of a terminal 50 is shown. The gantry 52, is disposed to remain below the bottom of the passenger loading bridge 51 even when the passenger loading bridge is lowered to the ground. As such, only the length of the passenger loading bridge is altered to increase or decrease the height of aircraft entrance to which such a passenger loading bridge can be coupled. Referring to Fig. 5b, a ground level terminal 53 is shown coupled to an passenger loading bridge 51. The passenger loading bridge 51 is capable of being raised and lowered by a gantry 52. Unfortunately, even when lowered to just clear the gantry 52, the lowest an aircraft entrance can be is  $\Delta x$  above the ground. Due to the large size of the gantry wheels and the small size of some commuter aircraft, the height  $\Delta x$  is above a base of an entrance for the smaller aircraft.

Alternatively, a plurality of support arms disposed in pairs, each pair hingedly joined at a centre thereof and adjacent pairs joined to one another by connecting an end of each support arm within each pair to a single end of a support arm in an adjacent pair. This forms a scissors like structure for extending and retracting. Devices of this type are well known and understood. A hydraulic or other piston member disposed between pair ends of a first pair, drives the pairs apart or together. Disposing such a device below the head unit, allows the head unit to be raised and lowered through the action of the piston while retaining the a substantially low profile and allowing the head unit to descend to a location substantially proximate a top of the gantry frame. By positioning the support

arms along the longitudinal axis of the head unit, a minimum number of support arms is required since the support arm length can be longer than in the transverse orientation.

Referring to Fig. 6, a detailed top view of the walkway is shown. The interface unit in the form of a valet unit 102 is coupled to the rotunda 104. The rotunda 104 is shown to revolve about a central point P; this need not be. The gantry wheels 132 are shown angled somewhat beneath the head unit 120 mounted on the gantry frame 134. This permits comfortable travel through an arc without wheel slippage and extensive tire wear. Also, give in the wheel mount assembly provides greater stability to the hydraulic members for raising and lowering the head unit 120.

The head unit 120 is provided with an aircraft interface 140 in a side thereof. The aircraft interface 140 is disposed on a telescoping section 124 of the head unit 120 allowing for more accurate alignment of the aircraft interface 140 and the aircraft entrance. The aircraft interface 140 is provided with a bumper 142 along the floor thereof for engaging the outside of an aircraft near the entrance. A gasket 144 surrounding the top and sides of the aircraft interface 140 is for extending to contact the aircraft above the entrance. The gasket 144 serves to protect passengers from the elements while emplaning or deplaning.

Because of the different locations of aircraft entrances, the different sizes of aircraft, and the different curvature of aircraft hulls, the gasket 144 is provided with a number of extenders 146 providing complex motion comprising an angular adjustment and a telescoping means. The combination of the motions allows the gasket 144 to be extended to meet with the hull of the plane at a point above the entrance. Alternatively, the gasket 144 is provided with another form of actuation permitting it to engage the top of the aircraft entrance.

When engaging an aircraft, the header unit 120 is moved proximate the aircraft entrance. The aircraft interface 140 is then aligned with the entrance to the aircraft and the



header unit 120 is moved to engage the aircraft -the bumper 142 contacts the aircraft hull below the aircraft entrance. The gasket 144 is extended to complete the covered walkway from the airport terminal to the aircraft entrance.

When the aircraft is provided with steps on the inside of the door and the steps  
5 have a railing - this is common on the Dash 8<sup>®</sup> - two flaps 148 in the floor of the aircraft interface 140 proximate the bumper 142 are opened to allow the railings from the aircraft to extend through the floor of the aircraft interface 140. This allows for better positioning of the aircraft interface 140 and improved comfort for passengers emplaning or deplaning from an aircraft provided with steps and a railing.

10 Controls for the passenger loading bridge are located proximate the bumper 142 to allow for accurate docking with the aircraft and to minimise the potential for damaging the aircraft or passenger loading bridge.

Referring to Fig. 7, detailed drawings of the rotunda are presented. Referring to Fig. 7a, a top view of the rotunda is shown. The rotunda is provided with an edge strip  
15 105 for interfacing with the valet unit 102. A roof skin 103 covering the rotunda, a bellows 107, and a walkway unit interface 109.

Referring to Fig. 7b, a frame structure for the rotunda is shown. The frame is provided with a structural frame 150 mounted on a plurality of levelling jack feet 152. The levelling jack feet 152 are adjusted during installation and require no further  
20 adjustment. This permits the use of inexpensive manual jack feet as are well known in the art. The frame is formed of a base, side walls, and a roof support structure. No pillars or other extraneous supports are used. This provides a clear path through the rotunda 104 during operation. A side coiling curtain 111 (only one of the side coiling curtains is shown at the back of the frame) is disposed around the outside of the rotunda 104 to  
25 allow access to render the rotunda 104 substantially impervious to the elements while

permitting entry and exit from the rotunda 104. The side coil curtain on the front of the rotunda is not shown in Fig. 7b in order to show interior details.

Referring to Fig. 7c, an outside side view of the rotunda 104 is presented. The interface edge strip 105 is coupled to the fixed rotunda frame 104a. Upon the rotunda  
5 fixed frame 104a rests the rotunda rotating frame 104b. The rotating frame 104b is coupled to the walkway unit 110a (not shown) by way of the bellows 107 and the bellows interface frame 109. The bellows 107 is supported by the hinged bellows interface frame 109 allowing some angular movement between the walkway unit 110a and the rotating frame 104b. The angular movement is better seen in Fig. 3. The side coiling curtain 111  
10 wraps around the outside of the rotunda 104 forming side walls on opposing sides of the frame 150. When the rotunda rotating frame 104b is rotated, a side coiling curtain 111 extends while the other side coiling curtain 111 is retracted behind the side coiling curtain exterior skin 111a and rolled up. The bellows interface frame 109 is supported by a pivot pin 154 held in place by a shaft retainer 156 and allowing for pivotal movement of the  
15 bellows interface frame 109 about the pivot pin 154. This allows for raising and lowering of the head unit 120 without producing excessive stress on the rotunda frames 104a and 104b. A cross sectional view of the line EE of Fig. 7a with details of the pivot pin 154 and shaft retainer 156 is shown in Fig. 7d.

Referring to Fig. 7e, a cross sectional view along the roof of the rotunda 104  
20 along line AA of Fig. 7a is shown. The roof skin 103 is shown to form a substantially sealed roof for the rotunda 104 in order to provide comfort for passengers whilst boarding a plane. The roof forms part of the fixed rotunda structure and is attached to the fixed rotunda frame 104a; it does not rotate. Alternatively, the roof rotates and the fixed rotunda frame 104a comprises an interface for coupling with the valet unit 102 and a base  
25 on which the rotunda rotating frame 104b rotates.

The roof of the rotunda 104 is supported by the fixed frame 104a. To the fixed frame 104a is attached the roof skin 103 by a rivet 212. Below the outer roof skin 103a is

fibreglass batt insulation 214 separating the outer roof skin 103a from the inner roof skin 103b. The roof skin is stretched across the roof from support 216 to support. At each support the roof skin is capped as shown in Fig. 7g. At the rotunda wall proximate the bellows 107, cove moulding 222 is used to form a visually pleasing seal between the inner roof skin 103b and the rotating frame 104b. The rotating frame 104b is connected to the top bellows closure strip 218 which is in turn connected to the top of bellows 107. The bellows frame 109 also acts as a support for the rotunda roof support 220 which rests on the bellows frame 109 but is not connected thereto, thereby allowing for relative motion between the rotunda roof and the bellows 107.

Referring to Fig. 7f, a cross sectional view of the rotunda floor along the line AA of Fig. 7a is shown. The fixed frame 104a is provided with an interface 105 for adjoining the valet unit 102. The base of the fixed frame 104a rests on the ground and is formed of two parallel circular rails 160 and 162 disposed one above the other. The rotating frame 104b is provided with CAM follower bearings 164 support wheels (not shown) disposed between the rails 160 and 162 and for allowing rotational movement of the rotating frame 104b. In use, lifting the head unit 120 results in some upward force on the rotating frame 104a at the end adjacent the walkway unit 110a. This upward force causes the wheels (not shown) at that end to roll against the upper rail 162. On the opposing side of the rotating frame 104b, the wheels (not shown) is forced downward according to known mechanical design principles and rolls on the lower rail 160. Of course, when no upward force is exerted upon the rotating frame 104b, the wheels (not shown) all roll along the lower rail 160. Alternatively, a single circular rail for supporting a plurality of pairs of wheels one wheel from each pair disposed on either side is used for a same purpose.

A platform frame 104c upon which is rested a plywood floor 104d forms part of the fixed frame 104a. Alternatively, floors formed of other suitable material are used. A transition ramp 166 made from a substantially thin material to prevent stumbling is disposed between the plywood fixed floor 104d and the floor of the walkway unit 110a

which rotate about the rotunda 104. As is seen in the drawing, the bellows 107 is coupled at one end to the rotating frame 104b and at the other end to the bellows interface frame 109 coupled to the rotating frame 104b by way of the pivot pin 154.

Referring to Fig. 7g, a drawing of the roof skin seal 103a is presented. Of course  
5 the roof skin 103 can be sealed in any of a number of fashions conventional in the art.

Referring to Fig. 7h, a cross sectional view of the rotunda along the line BB in Fig. 7a is shown. The view affords a detailed view of the side coiling curtain. As can be appreciated from the drawing, the side coiling curtain 111 rolls about a post 171 when the rotating frame 104b moves such that the side is reduced in length and unrolls to cover  
10 the additional exposed siding when the rotating frame 104b is rotated in an opposite direction. For increased protection and safety, the side coiling curtains 111 roll up inside an enclosure 172. The far end of the side coiling curtain 111 is fixed to the side wall 174 of the rotunda 104 that forms part of the rotating frame 104b. As the rotating frame rotates, the side wall 174 pushes or pulls on the side coiling curtain 111. At an opposing  
15 end of the side wall 174 is fixed the bellows 107 and then the bellows interface frame 109.

Referring to Fig. 7i, a cross sectional view of the rotunda along the line CC in Fig. 7a is shown. The view affords another detailed view of the rotational mechanism of the rotunda. The fixed frame 104a is provided with an interface 105 for adjoining the valet  
20 unit 102. The base of the fixed frame 104a rests on the ground and is formed of two parallel circular rails 160 and 162 disposed one above the other. The rotating frame 104b is provided with CAM follower bearings 164 support wheels 166 disposed between the rails 160 and 162 and for allowing rotational movement of the rotating frame 104b. In use, lifting the head unit 120 results in some upward force on the rotating frame 104a at  
25 the end adjacent the walkway unit 110a. This upward force causes the wheels 166 at that end to roll against the upper rail 162. On the opposing side of the rotating frame 104b, the wheels 166 is forced downward according to known mechanical design principles and

rolls on the lower rail 160. Of course, when no upward force is exerted upon the rotating frame 104b, the wheels 166 all roll along the lower rail 160.

Referring to Fig. 8, a diagram of the control panel is shown. The passenger loading bridge disclosed herein is provided with a novel user friendly control layout. The controls are provided in button pairs wherein each button for performing an action and the button for performing an opposite action are adjacent one another, in a predetermined and consistent relation.

Button 251 controls floodlights disposed on the passenger loading bridge (not shown). Button 252 controls the auto leveller feature for levelling the head unit 120. Buttons 253 control the canopy. As the canopy is moved using 4 separate actuators to control angle and extension on each of the sides of the aircraft interface, each actuator is capable of being individually activated. Also, a group of actuators is capable of being actuated simultaneously. Buttons 255 provide controls for raising and lowering the head unit 120. Buttons 257 provide for high speed traverse. A large button 258 provides power for the unit and is used mainly in its function as an emergency stop; without power, motion will cease. Each button actuates a function. The function is then controlled by joystick 259. The joystick allows for a fast and a slow speed of motion. Alternatively, a plurality of speeds in excess of two or an analogue variable speed system is implemented using the joystick 259. The joystick 259 operates when a button is pressed and has no function in the absence of a depressed button. Of course other configurations of joystick operation are possible and are dependent on safety regulations and concerns.

Using the layout shown in Fig. 8, the buttons are disposed right to left in the order they are required for engaging the loading bridge with the aircraft. Consequently, the buttons are disposed from left to right in the order they are used to disengage the bridge from the aircraft. The joystick operates in an intuitive fashion resulting in selecting at least a button from each group from right to left and moving the appropriate portion of the passenger loading bridge with the joystick until the positioning is as desired. Then, a

next button is selected. In a preferred embodiment, joystick motion is in a direction of walkway motion. For example, moving the joystick to the right causes the gantry wheels to rotated moving the head unit to the right. Moving the joystick forward causes the extensible section of the head unit to extend in a generally forward direction.

5           Heretofore, control panels for use with passenger loading bridges have been difficult to learn to use. The incorporation of an easy to use control panel and a plurality of sensors as described hereinbelow, allows less experienced operators to manoeuvre the passenger loading bridge with minimum risk of property damage, few safety concerns and little training. Also, training of new operators is rendered less costly because it is  
10           unlikely an operator will damage an aircraft so fewer experienced operators can train a plurality of new operators simultaneously. Heretofore, an experienced operator was dedicated to the task of training a new operator until safety of personnel, aircraft, vehicles, and luggage was assured. Further, ergonomic controls result in fewer operator errors and therefore in reduced damage and liability.

15           Commonly, control panels for use in passenger loading bridges are provided with a plurality of security features such as requiring the pressing of numerous buttons simultaneously in order to actuate the gantry 130. Referring to Figs. 9a, 9b and 9c, the control panel 200 is provided on a flip out console. The flip out console 200 is mounted on hinges 202 and is held in a first position by latches 204 and in a second "flipped-out"  
20           position by a stop 206 (shown in Fig. 9c).

          When "flipped-out," controls are activated by pressing a button. The activation continues while a button is pressed and terminates upon releasing all button. For security, once the passenger loading bridge is in place, the console is moved to a "flipped-in" position (shown in Fig. 9a) and the buttons are hidden from view or from accidental  
25           activation. Optionally, when in this position, the buttons are disabled. Optionally, a key

lock is provided to disable operation of the control panel or to prevent unauthorised access to the panel.

Referring to Fig. 10, the gantry 130 comprises a platform 134. The platform 134 is structural and is capable of supporting the weight of the lifted portion of the passenger loading bridge. The gantry platform 134 supports two support beams 124 (not shown) on either side of the head unit 120 for raising and lowering the head unit 120. The support beams 124 are fitted with a vertical power unit 138 in the form of a hydraulic drive to provide power for lifting and for lowering the head unit 120 in a controlled fashion. Because the support beams 124 are disposed beside the head unit 120, the head unit 120 can be lowered to rest on the gantry frame 134.

To the gantry 130 are also connected two pairs of wheels 132. Two of the wheels 132a are driven for moving the gantry 130 laterally. The other two wheels 132b, disposed at the opposing end of the gantry 130 provide stability during motion of the gantry 130 and during rest. The wheels 132 are supported by axles 133 disposed above the frame 134. The placement of the wheels 132 above the gantry frame 134 allows a simple rectangular frame construction and permits the head unit 120 to be lowered to a level substantially near the ground. Further, the gantry configuration shown in Figs. 10a, 10b, 10c, 10d and 10e allows extremely large gantry wheels 132 without raising the minimum height of the head unit 120. Large wheels are desirable when obstacles such as uneven ground or pot holes are of concern. Large wheels also permit the support of heavier structures.

Because the radius of curvature of the gantry 130 during lateral movement is fixed, the wheels 132 are turned in slightly to accommodate the arc that is traversed during movement of the passenger loading bridge.

As is seen in Fig. 10b the gantry frame 134 is disposed above the ground by a clearance distance D to allow for unobstructed motion in the lateral direction when the

wheels 132 are driven. The gantry frame construction is dependent upon the weight of the passenger loading bridge requiring support. Therefore, the minimum height of the passenger loading bridge at the gantry 130 is the clearance distance D plus the frame thickness T plus the thickness of the passenger bridge underside and floor. This distance  
5 is also determinative of the lowest aircraft entrance with which the passenger loading bridge can engage.

Since the gantry frame 134 extends beyond the sides of the head unit 120, there is a potential that the gantry wheels 132 could damage an aircraft by hitting the aircraft steps or the like. Therefore, the gantry 130 is positioned behind the aircraft interface 140  
10 by a sufficient distance to clear any steps, railings, and propellers of supported aircraft. Alternatively, the aircraft interface 140 extends from an end of the passenger loading bridge instead of at a right angle and allows for the opening and the wheels to not interfere with each other.

Of course, it is evident from the drawings that when the wheels 132 are disposed  
15 beneath the aircraft interface 140 that the aircraft interface 140 can not be lowered below the top of the wheels 132. This is undesirable. Disposing the wheels 132 on either side of the head unit 120 and on either side of the aircraft interface 140 requires a substantial structural support frame for the gantry 130 and is therefore, less desirable than the embodiment shown in the figures. Also of note is that the hydraulic power unit presents  
20 the same concerns. Disposing the hydraulic unit beneath the walkway is, therefor, undesirable. As can be seen in the figures, the hydraulic power unit is disposed on a side of the head unit 120 and not beneath it when the head unit is fully lowered.

Optionally, the rotunda 104 is elevated above ground level. This requires an interface unit 102 that slopes upward from the terminal 100 to the rotunda 104. With a  
25 configuration as shown in Fig. 1, the additional sloped element allows for an extra 2 feet of aircraft interface elevation and allows the aircraft interface 140 to be positioned lower than with the rotunda 104 at ground level. Preferably, when the rotunda 104 is positioned



2 feet above the ground, a base is placed below the rotunda 104, the base having a larger diameter than the rotunda 104. This base increases rotunda stability.

Referring to Fig. 11, a method of automatically adjusting the height of a passenger loading ramp is shown. An operator enters an aircraft type and where applicable an  
5 entrance on the aircraft. The control panel comprises a processor and non-volatile storage. In the non-volatile storage is a table of information regarding entrances to each aircraft. The selected aircraft entrance is located in the table and a height is determined. The height is provided to the elevation means and the aircraft interface 140 is raised to substantially that height. Such a process reduces operator effort and improves efficiency  
10 by accurately aligning the bridge with the aircraft entrance height automatically.

Referring again to Fig. 6, a detailed drawing of the head unit 120 shows a plurality of sensors 230 disposed about the periphery of the head unit. These sensors serve a variety of functions described hereinbelow.

It is uncommon to use a passenger loading bridge with small aircraft. As  
15 described above, clearance between aircraft features such as propellers and entrances are significantly less than with jumbo jets. Because a passenger loading bridge often costs orders of magnitude less than aircraft, there is considerable concern over aircraft damage. Aligning a bridge with an entrance of a small aircraft is very difficult and prone to error. An obvious way of accomplishing this task is having an individual communicating by  
20 radio to indicate to an operator current status and problems. In order to obviate the individual, a window was placed in the passenger loading bridge. Unfortunately, due to small clearances between the aircraft entrance and propeller and some features extending beyond the sides and end of the passenger loading bridge, sufficient view to prevent damage consistently was not afforded by the window.

25 Due to the high cost of damage to an aircraft in terms of customer dissatisfaction, delays, insurance, possible injury, etc., it is imperative that engaging the aircraft entrance

be accomplished with minimum risk to an aircraft. For Jumbo jets this was not an issue due to significant clearance between the jets and the entrance; however, without a reliable system for preventing aircraft damage, passenger loading bridges are unlikely to gain acceptance with small aircraft.

5           The sensors 230r are disposed adjacent the handrail slots 148 in the floor of the aircraft interface 140 proximate the bumper 142. The sensors detect a presence and/or location of an object proximate the bumper. Examples of sensors that are suited for such an application include sonar, proximity detector sensors, electromagnetic sensors, light beam sensors disposed at a plurality of locations to detect the presence of an opaque  
10   object breaking a beam of light, etc. Further sensors 230p are disposed in locations along the side of the passenger loading bridge where the bridge may strike an aircraft propeller. Other sensors 230s are disposed to detect the presence of people or vehicles on the tarmac and in the path of the passenger loading bridge during positioning. Of course, many other sensor locations are used depending on common collisions or near collisions and on the  
15   intended use of the passenger loading bridge and its sensors. The sensors are used in any of a number of ways some of which are outlined below with reference to Figs. 13-15.

Referring to Fig. 12, a simplified flow diagram of a method of engaging the aircraft interface 140 with an aircraft entrance is shown. The type of aircraft is provided to the control panel. The input for this is provided by a keyboard or mouse as is  
20   conventionally used with personal computers. Alternatively, a dial is provided for selecting a height or an aircraft type. The bumper 142 is automatically raised to a known height for the selected aircraft. At this height, the bumper should engage the aircraft substantially below the entrance thereof. The gantry 130 is swung into place proximate the aircraft slowly. As the gantry approaches the aircraft, the extensible section of the  
25   head unit 120 is extended or retracted to align the aircraft interface 140 and the entrance to the aircraft. The gantry 130 again is used to move the head unit 120 to engage the aircraft. When a sensor detects the presence of an object proximate the passenger loading

bridge in a location where no object should correctly be, the operator is informed of this fact. For example, when an object such as a railing is detected 6 inches from the railing slot 148 along the bumper, the operator is appraised of this information and can stop the gantry and extend or retract the extensible portion of the head unit to ensure proper alignment. Upon achieving proper alignment, the sensors provide feedback to the operator that such is the case.

Similarly, while operating the gantry to swing the passenger loading bridge into position, the sensors may detect an aircraft propeller. The cost of hitting an aircraft propeller with a passenger loading bridge is significant, and the additional safety feature of sensors disposed at outlying points on the passenger loading bridge provide an advantage of increased safety by detecting collisions with people, reduced property damage and consequently improved efficiency. These and other advantages will be evident from this disclosure.

Referring to Fig. 13, a simplified flow diagram of a method of automatically aligning the passenger loading bridge of Fig. 12 with the entrance of an aircraft is shown. Preferably, the control system for the passenger loading bridge is trained according to known training techniques in order to optimise alignment for a particular installation. Training of passenger loading bridges is discussed below. The aircraft type is provided by an operator. The operator need not be on the bridge and often, the operator is not at the airport terminal. When all flights are scheduled at a central location, the central location provides the aircraft type to the loading bridges using a communications network. Optical, wireless or digital communications networks such as an Ethernet network are applicable to this method.

The gantry 130 is controlled to raise the aircraft interface to the known height for aircraft of the type provided. A method similar to that of Fig. 11 is used. Alternatively, during training, aircraft heights are learned and incorporated into the alignment procedure for each aircraft. Once at the known height, the gantry 130 is swung slowly toward the

aircraft. When learning has occurred, the aircraft interface 140 is extended to a predetermined optimal extension. When learning has not been used, preferably, the aircraft interface 140 is extended completely or retracted completely. During the swinging of the passenger loading bridge, sensors 230 disposed at a plurality of locations  
5 on the bridge, detect a presence or absence of objects in the path of the bridge. When an object is detected, the gantry 130 is stopped and the head unit 120 is extended until the object is cleared or until it is fully extended. When fully extended, the head unit 120 returns to its previous extension and indicates an error and a location of the object that is causing the problem. An operator is then required to clear the object from the path before  
10 engagement can proceed. Of course, should the object move on its own, the bridge controller indicates all clear and waits a predetermined length of time to ensure safety before moving. Then the engagement process continues.

It is evident to those of skill in the art that when the object is detected at the free end of the head unit 120, the head unit 120 is not extended further but may be retracted in  
15 some instances.

As the aircraft interface 140 approaches the aircraft, the sensors 230 detect the presence of the aircraft. Preferably a more accurate sensor 230u such as an ultrasound sensor is used to align the bumper 142 and the entrance to the aircraft. The use of a distance measuring sensor such as ultrasound, enables the readings of other sensors to be  
20 evaluated for accuracy and for potential problems. Of course, at no point on the passenger loading bridge except the bumper 142 should contact with the aircraft occur so the absence of a range sensor does not prevent application of the method of Fig. 14. Once aligned, the control system indicates such and an operator traverses the passenger loading bridge into the aircraft to ensure correct engagement. Then passengers can emplane or  
25 deplane. Optionally, once aligned, the head unit 120 is raised or lowered a small amount to determine if the height was in fact correct and to more precisely engage the base of the aircraft entrance. In an embodiment, the auto-leveller performs this function.

In another embodiment, the entrance to the aircraft is fitted with a transmitter in the form of an RF transmitter for providing a wireless signal. The passenger loading bridge is provided with a sensor for sensing the transmitted signal, for determining a location of the transmitter, and for moving the aircraft interface toward the signal source.

5 Absent, sensors 230, the passenger loading bridge is liable to strike a wing, propeller, or other part of the aircraft during motion. It is, therefore, preferable that the passenger loading bridge have disposed thereon sensors 230 for detecting the presence of objects proximate the loading bridge. The sensors 230 also increase safety.

10 It is apparent to those of skill in the art that placing a transmitter at the entrance to an aircraft is far less time consuming than engaging a passenger loading bridge to an aircraft entrance. As such, efficiency is improved.

Referring to Fig. 14a, a method of training the automatic alignment system is presented. Over a period of several months, an experienced operator enters the aircraft type to be engaged and proceeds to manually engage the aircraft. With each engagement,  
15 data is collected indicative of typical engagement practices for each aircraft type. This method is suitable for use with an expert system.

Referring to Fig. 14b, another method of training the automatic alignment system is presented. The system is adapted for use with neural networks or other learning systems based on machine intelligence. For each aircraft, an attempt is made by the  
20 system to engage the aircraft. The attempt may follow a method similar to that outlined with reference to Fig. 13. Errors in the engagement are noted by an operator and provided to the control system. The control system incorporates these "errors" into its learning process. Over time, it is expected that the engagement accuracy should improve and that operator verification of engagement and further entry of errors is obviated. Training in  
25 such a manner allows the engagement method design to remain generic while training compensates for specific issues that arise at a particular location or terminal.

In an embodiment, the automatic alignment system comprises a neural network of a conventional type. The network comprises a plurality of nodes including input nodes, output nodes and an optional number of hidden nodes. Neural network design is well known in the art of computer science and more particularly in the art of machine  
5 learning. Some signals from sensor are provided to input nodes and control signals are provided as outputs. Disposed therebetween is a series of weighted summing nodes for determining the control signals in dependence upon the input signals. During training, the weighted summing nodes are modified in a manner to provide the desired output control signals in response to predetermined input signals.

10 In training, a plurality of alignments of the passenger loading bridge and the entrance to different types of aircraft are performed by experienced operators. With each alignment, the neural network gathers information and correlates the information to produce a trained control system. Neural network information gathering and training is well known in the art of machine learning. The training comprises weighting nodes of the  
15 neural network in order to generate responses to input information that substantially match responses provided with the training set for same input information.

When the sensors are for safety reasons and not intended for use in automatic engagement, the sensors 230 sense a presence of an object. When the object is likely to be hit by the passenger loading bridge - the object is in the path of motion of the bridge - one  
20 of the horizontal pivot means, the elevation means, and the horizontal pivot means and the elevation means is stopped. Selection of which to stop is dependent upon where the object is detected and a direction of the bridge's motion. When the object is no longer in the path of the passenger loading bridge, motion is resumed. Alternatively, when an object is detected, the bridge is moved so as to avoid the object but continue toward  
25 engaging the aircraft; when this is not possible, bridge motion is stopped.

Referring to Fig. 15, a diagram of the canopy extender 146 is shown. The canopy 144 is formed of conventional bellows. The extender 146 is formed of a supporting arm

146a hingedly connected to the aircraft interface 140 at a hinged connection 146b.

Coupled between the supporting arm 146a and the aircraft interface 140 is an hydraulic piston 146c swinging the supporting arm 146a about the hinged connection as shown at arrows S. To the supporting arm is coupled an end of a secondary arm 146d by a second  
5 hinged connection 146e. The secondary arm is swung about the second connection 146e by a second hydraulic piston 146f and swings through the arc L when the supporting arm is stationary. The opposing end of the secondary arm is coupled to the canopy 144.

In use, moving pistons 146c and 146f causes the canopy to moved according to a complex motion comprising both forward and downward motion. Preferably, supporting  
10 arm 146a provides substantially horizontal movement while secondary arm 146d provides substantially vertical movement of a top edge of the canopy 144.

Numerous other embodiments of the invention are envisaged without departing from the spirit and scope of the invention.

**Claims**

What is claimed is:

1. A passenger loading bridge for interconnecting an aircraft having an entrance therein with the ground level of an airport terminal building comprising:
  - 5 a walkway-conduit including:
    - a first open end,
    - an extensible section proximate an opposing end thereof comprising an aircraft interface for mating with the aircraft entrance,
    - elevation means for elevating the aircraft interface to allow the aircraft interface to
    - 10 engage each of a plurality of different sized commuter aircraft,, and
    - horizontal pivot means for pivoting the walkway about a rotunda;
  - the rotunda having a first open end coupled to the airport terminal building substantially at ground level and a second open end movable relative to said first open end of the rotunda, the second open end hingedly connected to the first open end of the walkway for
  - 15 allowing the rotunda to remain substantially level and for allowing the aircraft interface to be elevated, wherein the horizontal pivot means is for moving the second open end of the rotunda relative to the first open end of the rotunda..
2. The passenger loading bridge as defined in claim 1 wherein the walkway comprises:
  - 20 a first walkway portion hingedly coupled to the rotunda; and
  - a second walkway portion connected to the first walkway portion and angling downwardly from the connection when the first walkway portion is lowered to a fully lowered position, the second walkway portion having the aircraft interface disposed proximate an end thereof..
  - 25
3. A passenger loading bridge as defined in claim 1 wherein the open end of the rotunda is connected to two substantially circular rails disposed one above the other and wherein



the second open end in the rotunda is connected to a plurality of bearings disposed between the rails and each for rolling on one of the bottom rail and the top rail at a given time.

5 4. A passenger loading bridge as defined in claim 4 wherein the horizontal pivot means comprises a frame and wherein the elevation means is disposed in a location one of above or beside the conduit for allowing the walkway to be lowered to substantially about a top of the frame of the horizontal pivot means..

10 5. A passenger loading bridge as defined in claim 1 wherein the aircraft interface comprises a bumper disposed along the bottom of the aircraft interface for engaging the aircraft below the entrance, a gasket disposed substantially above the aircraft interface for engaging the aircraft above the entrance and for forming a protective covering for passengers passing between the aircraft and the passenger loading bridge.

15

6. A passenger loading bridge as defined in claim 6 wherein the bottom of the aircraft interface comprises a plurality of slots for accepting railings disposed on staircases proximate the aircraft entrance and forming part of the aircraft.

20 7. A passenger loading bridge for interconnecting an aircraft having an entrance therein with the ground level of an airport terminal building comprising:  
a walkway conduit including:

a first opening at an end thereof,

an extensible section proximate an opposing end thereof comprising an aircraft

25 interface for mating with the aircraft entrance,

elevation means for elevating the aircraft interface to allow the aircraft interface to engage each of a plurality of different sized commuter aircraft,

horizontal pivot means for pivoting the walkway about a rotunda, and

sensors for detecting the presence of an object proximate the walkway and for providing signals in dependence thereon;

the rotunda having a first opening connected to the airport terminal building substantially at ground level and a second opening movable relative to said first opening of the

5 rotunda, the second opening hingedly connected to the first opening in the walkway for allowing the rotunda to remain substantially level and for allowing the aircraft interface to be elevated, wherein the horizontal pivot means is for moving the second opening of the rotunda relative to the first opening of the rotunda; and,  
means responsive to the signals provided by the sensors for stopping at least one of the  
10 horizontal pivot means and the elevation means when an object is detected in a path of motion of the walkway.

8. A passenger loading bridge as defined in claim 7 wherein the means responsive to the signals comprises means for resuming motion of the at least one of the horizontal pivot  
15 means and the elevation means when the object is no longer detected in the path of motion.

9. A passenger loading bridge as defined in claim 7 wherein the means responsive to the signals comprises means for automatically aligning the aircraft interface and the entrance  
20 in dependence upon an indication of a type or size of aircraft and the signals.

10. A passenger loading bridge as defined in claim 7 wherein the aircraft interface is extensible in a substantially perpendicular direction to the direction of lateral motion of the walkway.  
25

11. A passenger loading bridge as defined in claim 7 wherein the sensors comprise a light source and a detector disposed to form a beam of light along an edge of the walkway, the

detector for detecting a presence or absence of light from the light source reaching the detector.

12. A method of automatically aligning the aircraft interface of the passenger loading bridge as defined in claim 7 and an entrance to the aircraft comprising the steps of:
- 5 determining an approximate height of the entrance;  
moving the aircraft interface to substantially the approximate height;  
moving the aircraft interface toward the aircraft;  
detecting a presence of objects in the path of movement of the passenger loading bridge  
10 using sensors;  
moving portions of the passenger loading bridge to avoid detected objects;  
in the presence of objects, stopping the passenger loading bridge motion until objects are cleared;  
upon approaching the aircraft, aligning the bumper of the aircraft interface with the  
15 entrance; and  
moving the aircraft interface to engage the aircraft with the bumper.

13. A method of automatically aligning the aircraft interface and the entrance to an aircraft as defined in claim 12 wherein the step of determining an approximate height of  
20 the entrance is performed by indicating an aircraft type and selecting a height corresponding to the aircraft type from stored values of aircraft heights.

14. A method of automatically aligning the aircraft interface and the entrance to an aircraft as defined in claim 12 wherein the step of determining an approximate height of  
25 the entrance is performed by indicating parameters relating to the aircraft dimensions.

15. A method of automatically aligning the aircraft interface and the entrance to an aircraft as defined in claim 12 wherein the step of moving the aircraft interface toward the

aircraft is performed by extending an end of the passenger loading bridge proximate the aircraft interface.

16. A method of automatically aligning the aircraft interface and the entrance to an aircraft as defined in claim 12 wherein the step of detecting a presence of objects in the path of movement of the passenger loading bridge using sensors is performed using sensors disposed at a plurality of locations about an outside surface of the passenger loading bridge.

17. A method of automatically aligning the aircraft interface and the entrance to an aircraft as defined in claim 12 wherein the step of upon approaching the aircraft, aligning the bumper of the aircraft interface with the entrance is performed in dependence upon a separate imaging sensor for identifying the entrance and detecting a location of the entrance.

18. A method of automatically aligning the aircraft interface and an entrance to an aircraft as defined in claim 12 wherein the step of upon approaching the aircraft, aligning the bumper of the aircraft interface with the entrance is performed in dependence upon a sensor for detecting railings on the aircraft stairs and a known location of slots for accepting the railings.

19. A method of automatically aligning the aircraft interface and the entrance to an aircraft as defined in claim 12 wherein some of the steps are performed in dependence upon previous training data.

20. A method of automatically aligning an aircraft interface of a passenger loading bridge and an entrance to an aircraft as defined in claim 19 wherein the steps are performed in by a controller comprising a neural network.

U.S. Patent

Jun. 11, 1996

Sheet 1 of 5

5,524,318

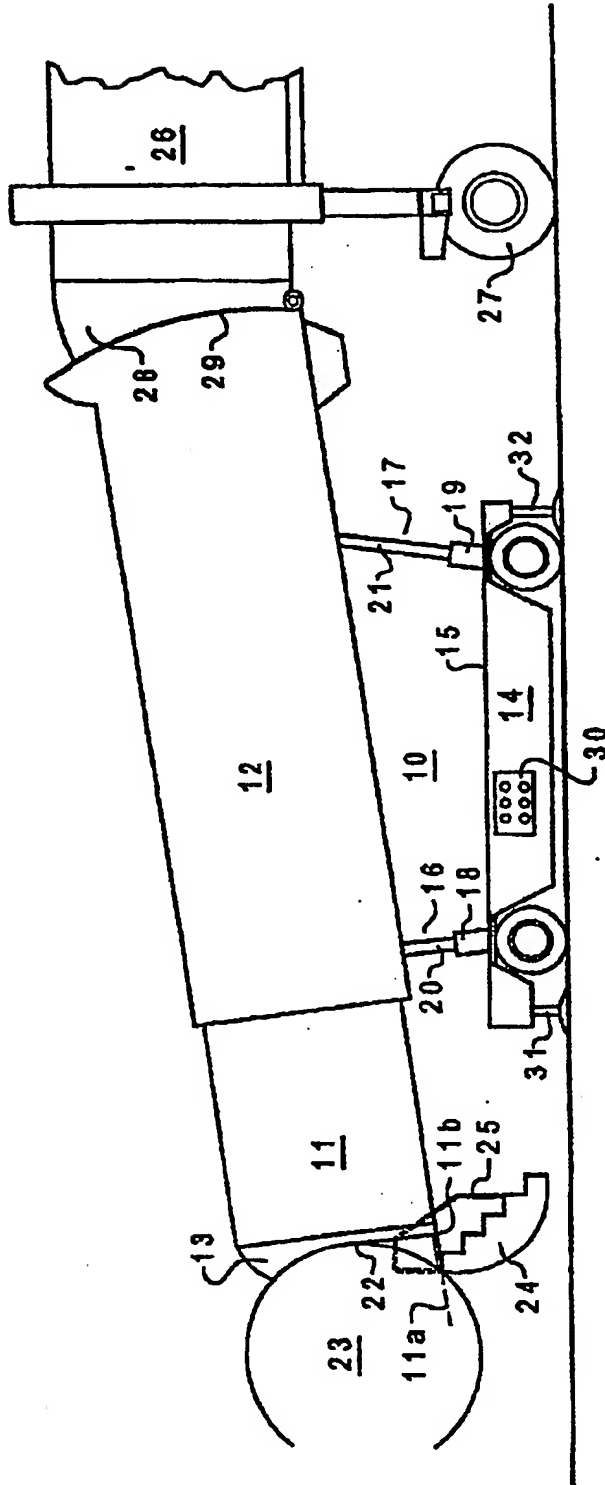
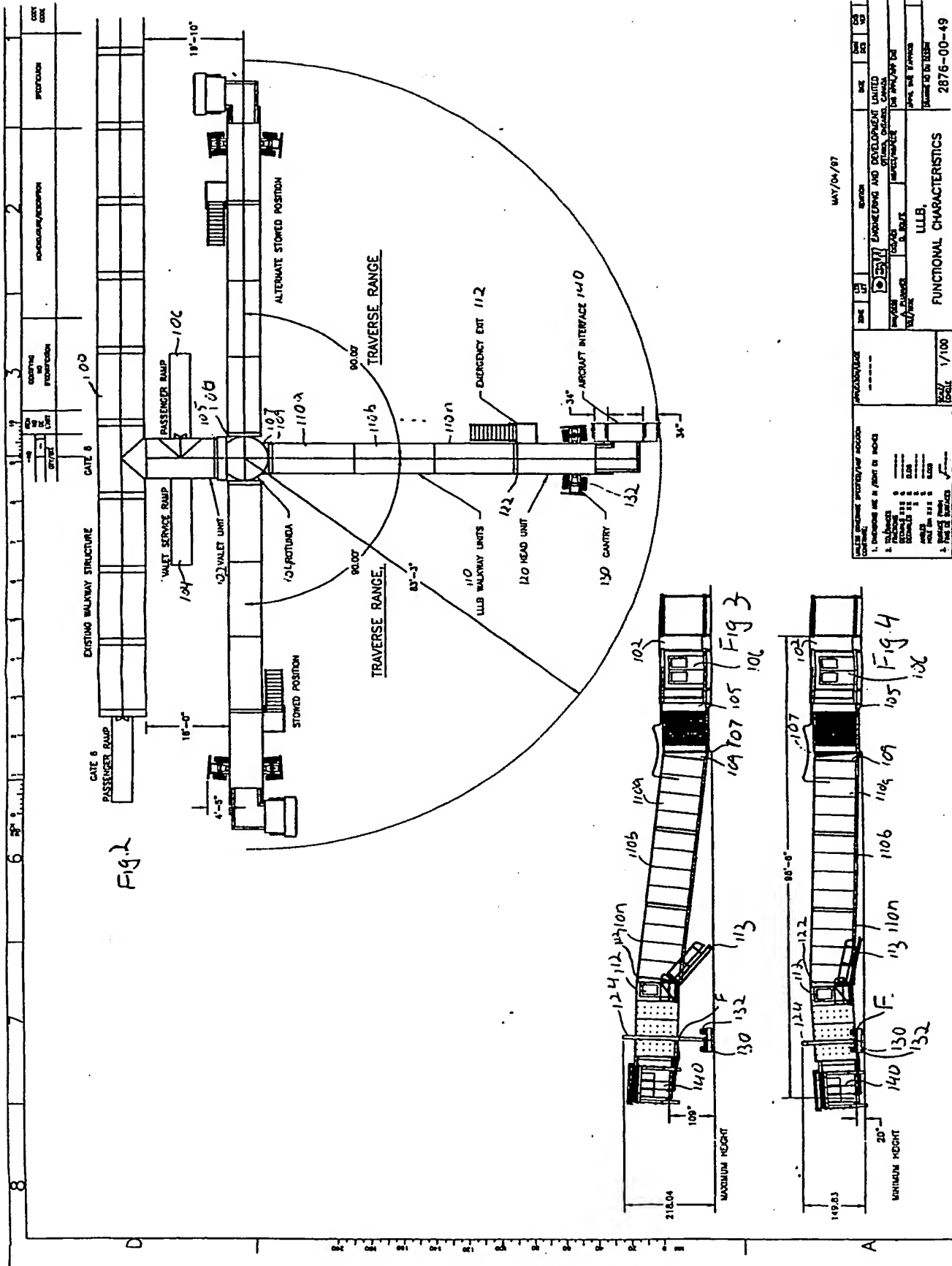


Fig. 1



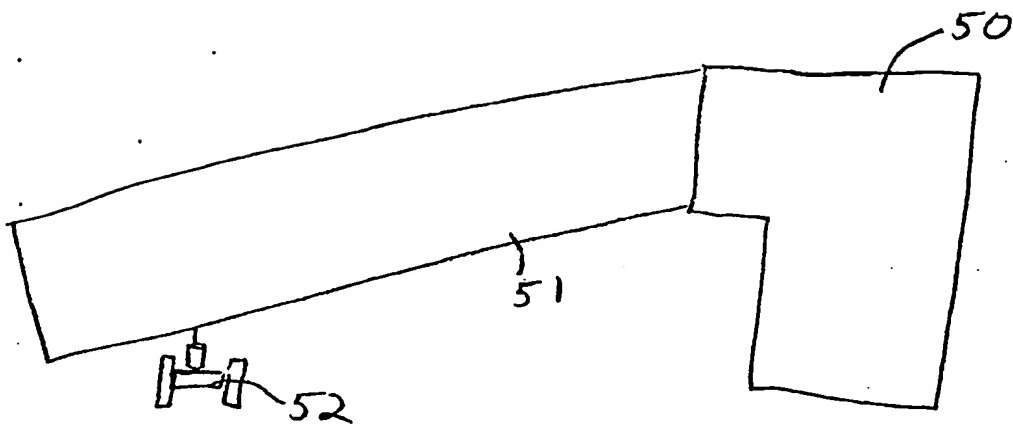


Fig. 5a

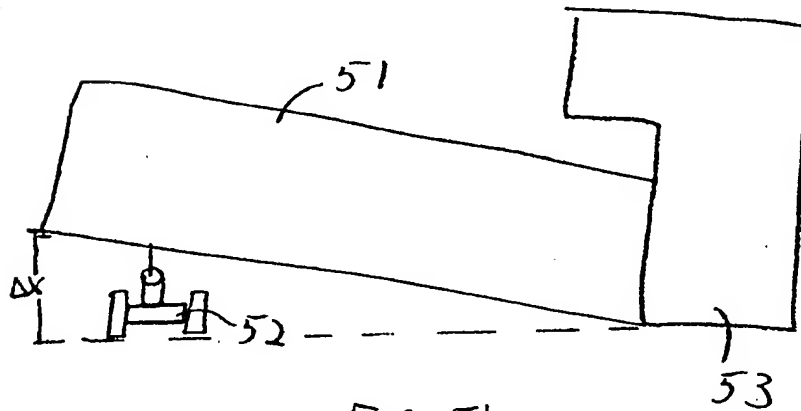
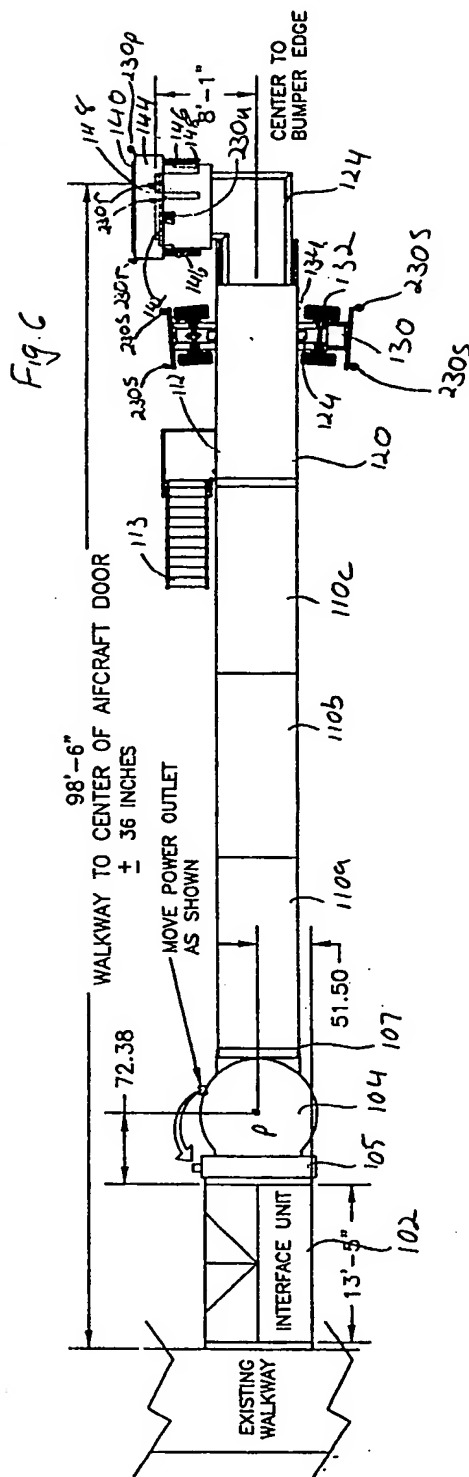


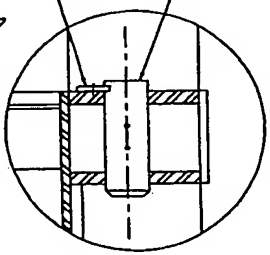
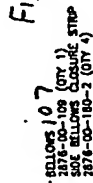
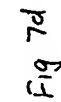
Fig. 5b



MAY/04/97

[illegible]





**SECTION EF**  
**514**

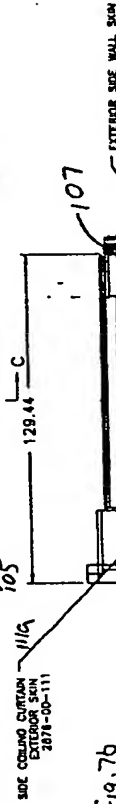


Fig. 7C

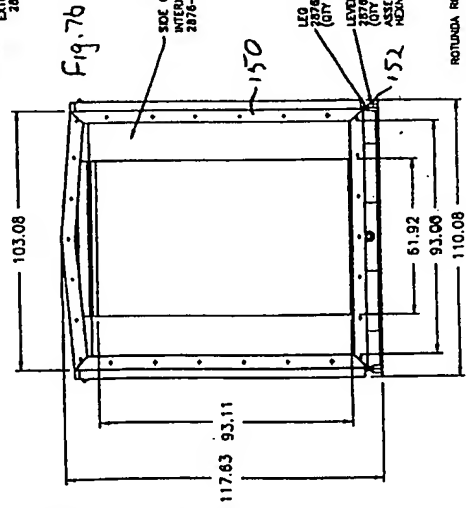
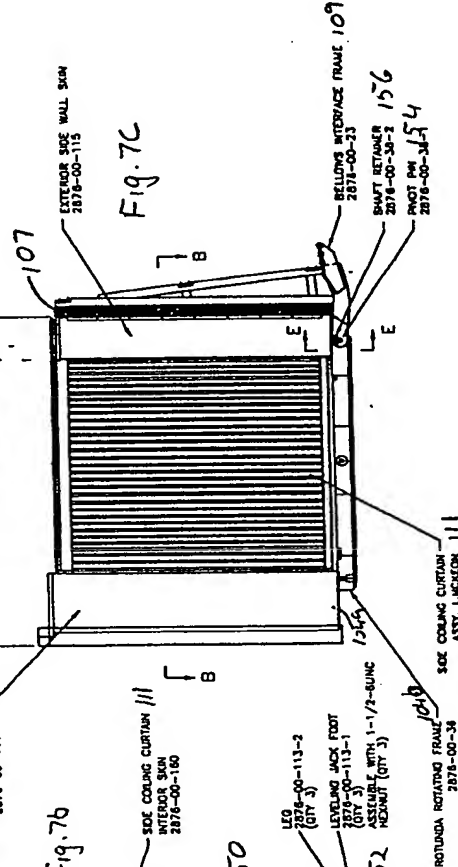


Fig. 7b



**EXPERIMENTAL INFORMATION**

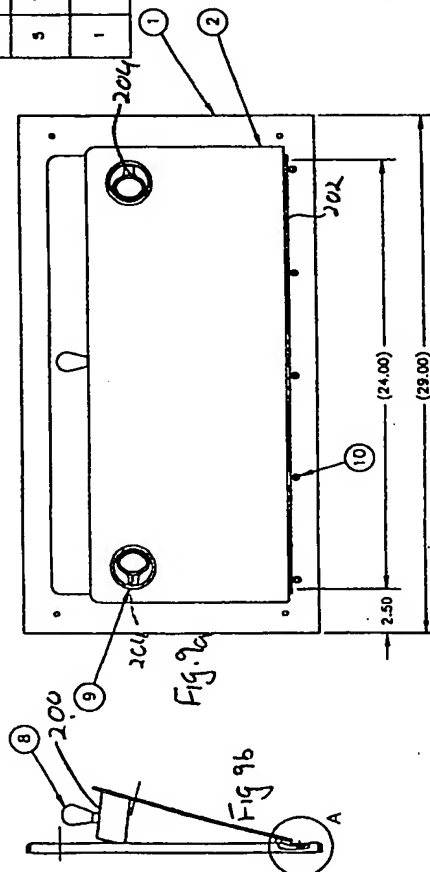
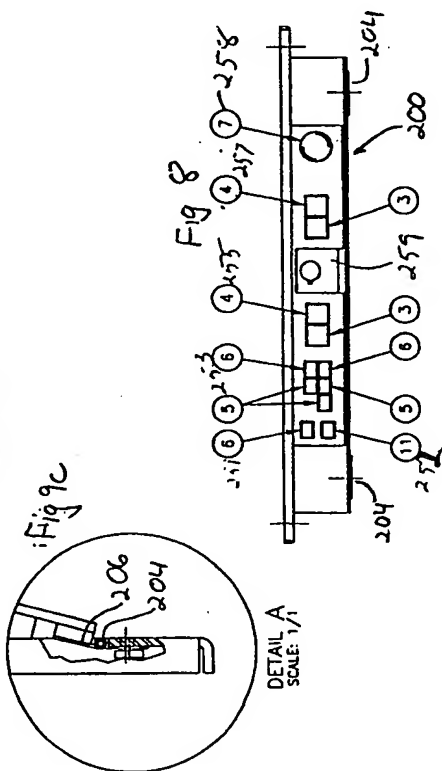
THIS DOCUMENT IS THE PROPERTY OF DOW ENGINEERING AND DEVELOPMENT LTD., NO REPLICATION OR TRANSFER OF ANY INFORMATION CONTAINED HEREIN IS PERMITTED IN THE ABSENCE OF AN AGREEMENT WITH DOW ENGINEERING AND DEVELOPMENT LTD., AND NEITHER THE DOCUMENT NOR ANY SUCH INFORMATION MAY BE RELEASED WITHOUT THE WRITTEN CONSENT OF DOW ENGINEERING AND DEVELOPMENT LTD.

[illegible]






A diagram of a hand saw blade showing the relationship between the set and the backset. The blade is curved to the left, with a label '20°' indicating the set angle. The backset, which is the distance from the set to the cutting edge, is also labeled '20°'.



**PROPRIETARY INFORMATION**

THIS DOCUMENT IS THE PROPERTY OF DEW ENGINEERING AND DEVELOPMENT LTD., NO EXPLOITATION OR TRANSFER OF ANY INFORMATION CONTAINED HEREIN IS PERMITTED IN THE ABSENCE OF AN AGREEMENT WITH DEW ENGINEERING AND DEVELOPMENT LTD., AND NEITHER THE DOCUMENT NOR ANY SUCH INFORMATION MAY BE RELEASED WITHOUT THE WRITTEN CONSENT OF DEW ENGINEERING AND DEVELOPMENT LTD.

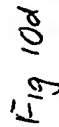
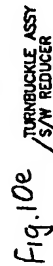
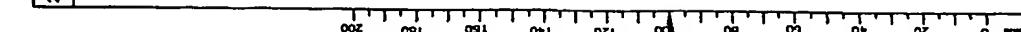
DEW ENGINEERING REVISIONS ONLY

A2	REVISED		97-04-02	AM					
A1	REVISED		98-10-07	R.S.					
ZONE	1/1	REVISION	DATE	BY	CHK	APP.	APP.	APP.	APP.
 <b>ENGINEERING AND DEVELOPMENT LIMITED</b> 1000 HWY 7 EAST, SUITE 100, MARKHAM, ONTARIO L3R 9V7 CANADA TEL: (905) 947-8888 FAX: (905) 947-8889									
OWNER	CONTRACT	PROJECT	PROJECT NO. 1000 HWY 7 EAST, SUITE 100, MARKHAM, ONTARIO L3R 9V7 CANADA TEL: (905) 947-8888 FAX: (905) 947-8889						
DATE	NO.	REV.	DATE DATE DOWNSHED 2876-00-218 1 8 1						
CONTROL PANEL ASSEMBLY									

## CONTROL PANEL ASSEMBLY

2876-00-218

10/1/88



THIS DOCUMENT IS THE PROPERTY OF DEW ENGINEERING AND DEVELOPMENT LTD., NO EXPLOITATION OR TRANSFER OF ANY INFORMATION CONTAINED HEREIN IS PERMITTED IN THE ABSENCE OF AN AGREEMENT WITH DEW ENGINEERING AND DEVELOPMENT LTD., AND NEITHER THE DOCUMENT NOR ANY SUCH INFORMATION MAY BE RELEASED WITHOUT THE WRITTEN CONSENT OF DEW ENGINEERING AND DEVELOPMENT LTD.

[illegible]

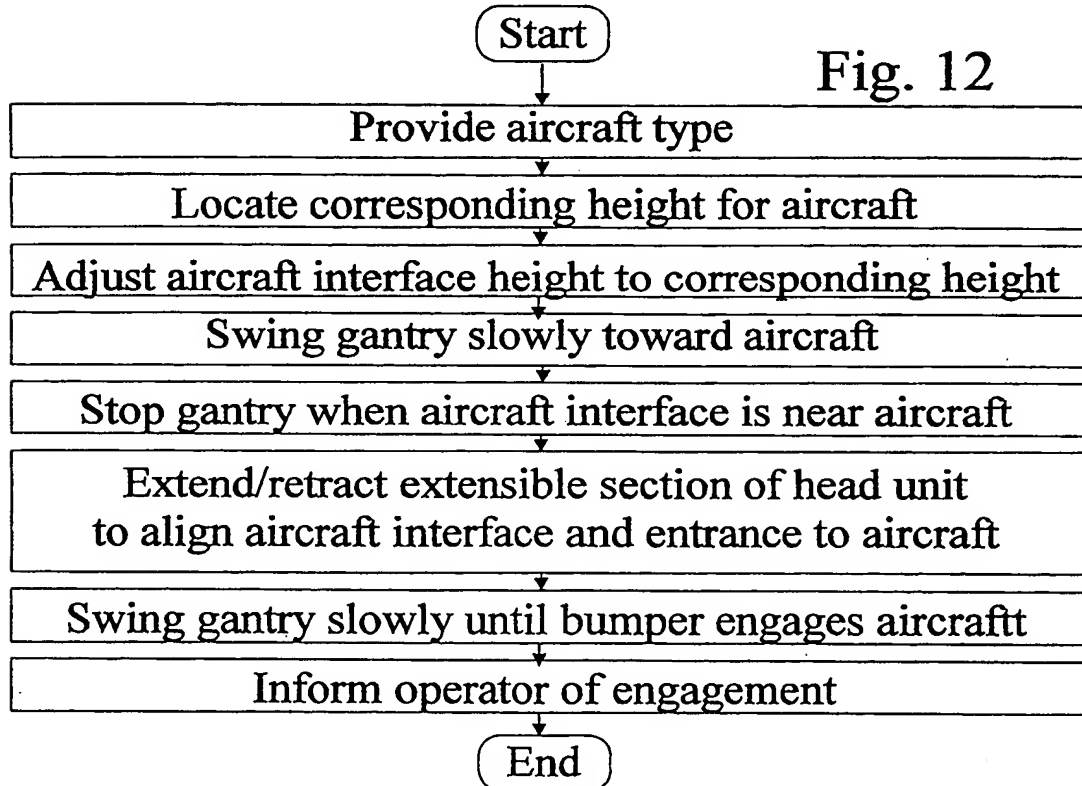
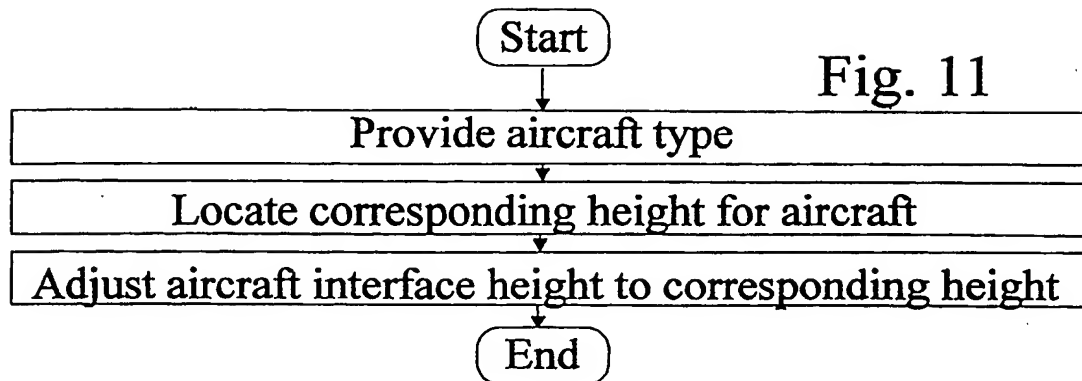


Fig. 13

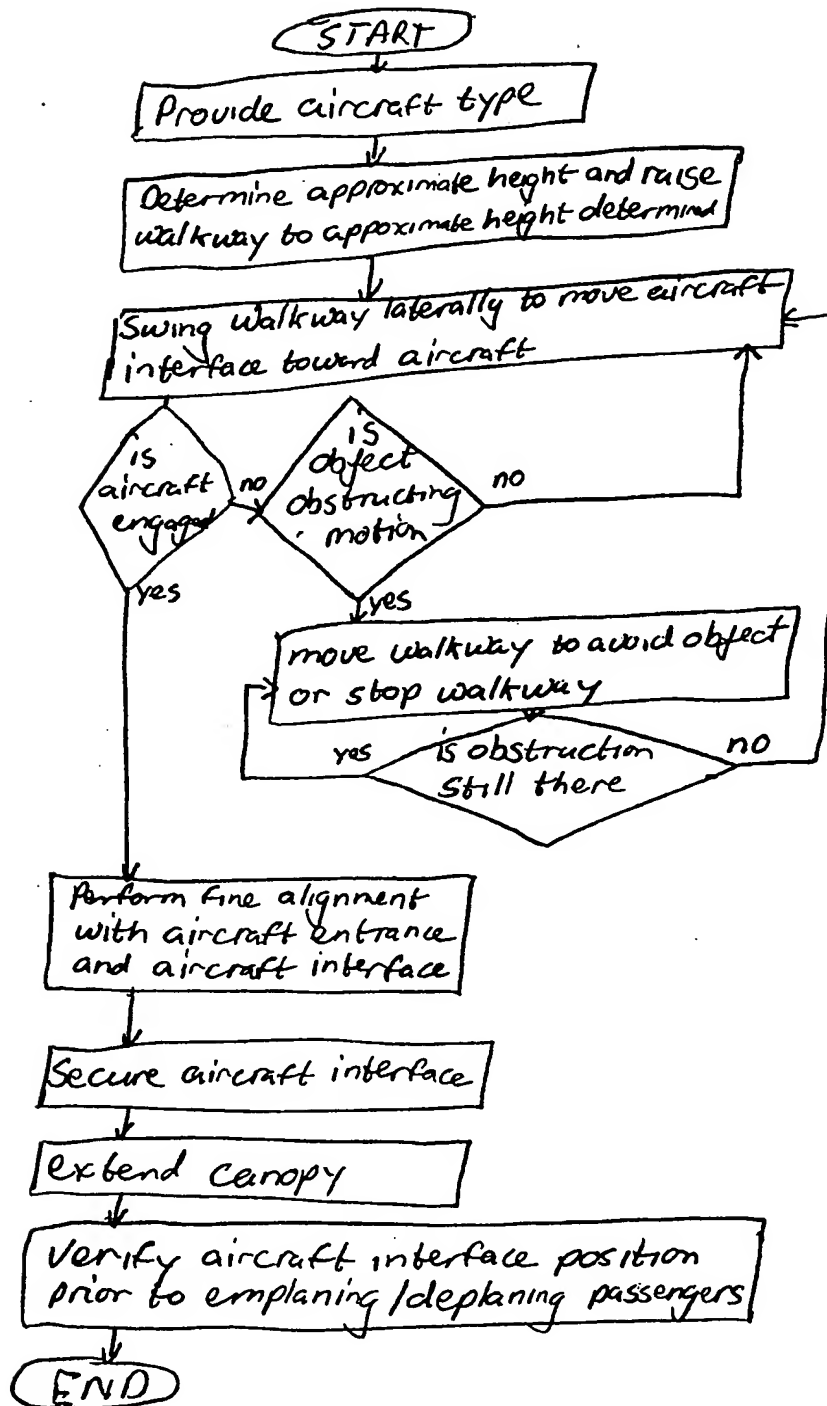
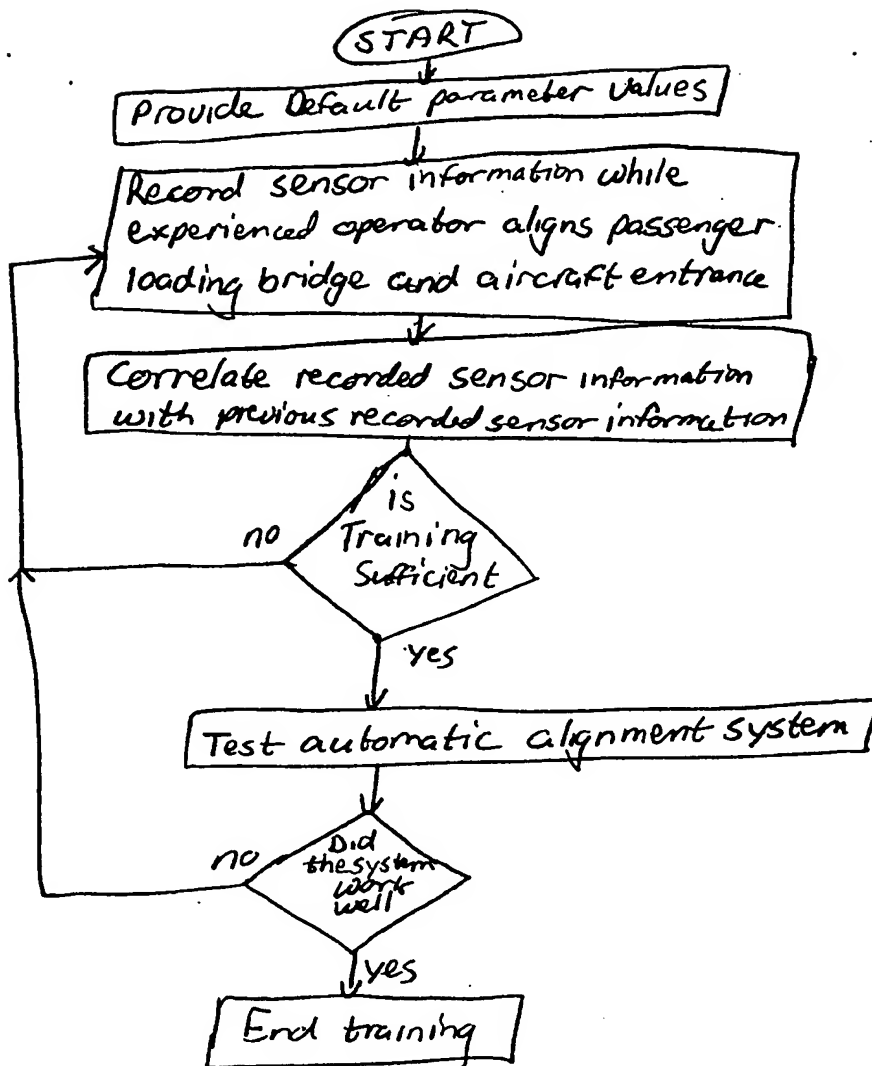


Fig. 14a





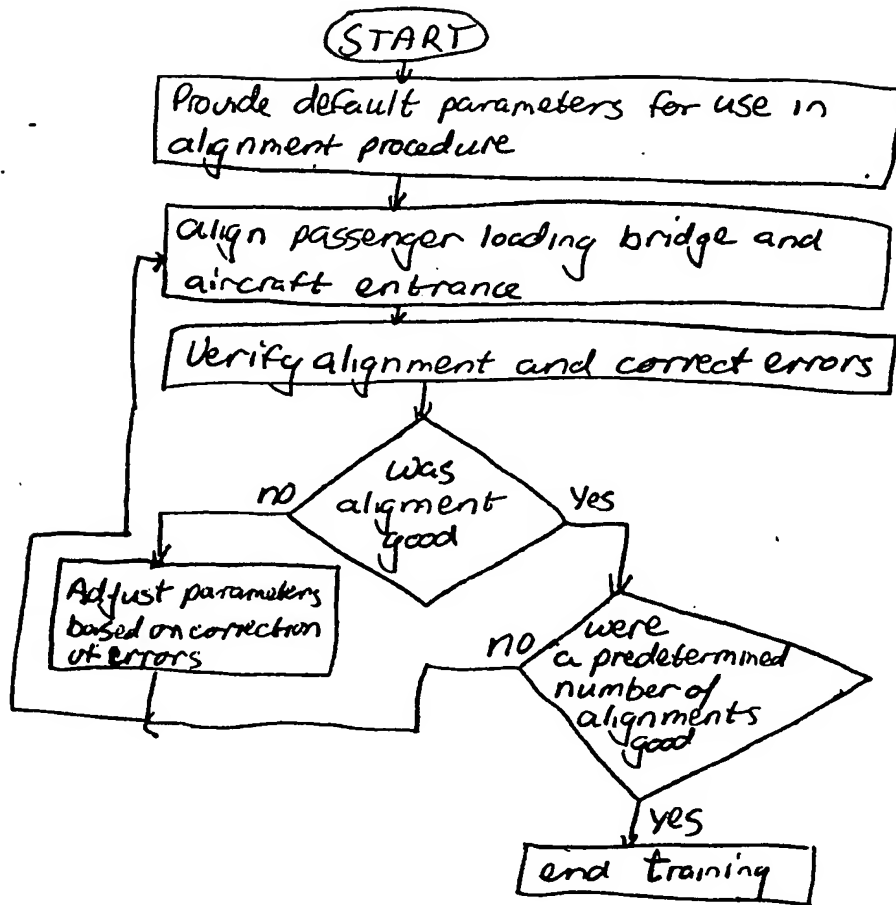


Fig. 14b

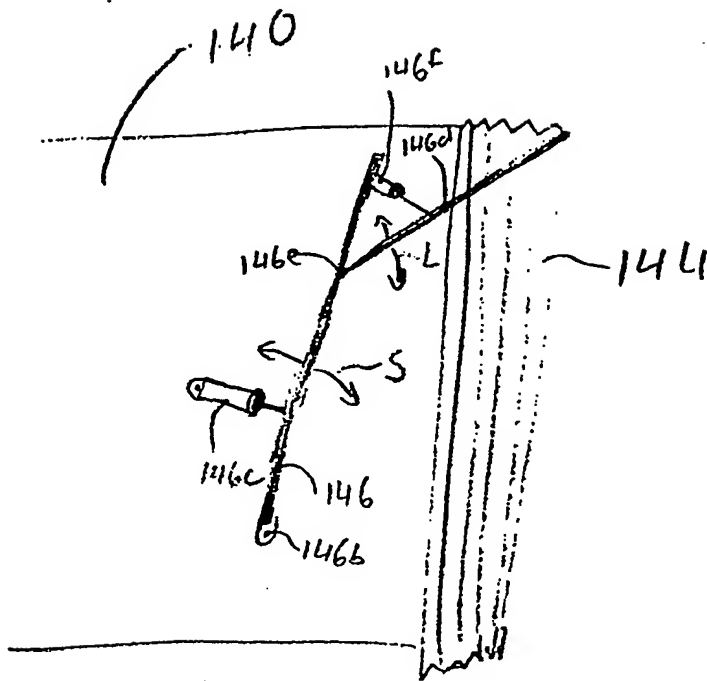


Fig. 15

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**